Final Report to NOAA Office of Global Programs

Project title:

"Improvement of Forecast Communication and Use between Indigenous and Governmental Groups in Australia: Managing Fire in Arid and Semi-Arid Lands under Conditions of Interannual Climate Variability"

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I. Preliminary Materials

A. Project Abstract

This project seeks to explore and remedy the barriers to communication that exist between traditional and scientific interannual climate forecasting. It proposes an analytical framework and a set of methodologies to examine three types of obstacles to communication (linguistic, conceptual and organizational differences). It integrates remote sensing with social science methods such as ethnography and interviews. It indicates a process to develop and evaluate projects that will address the obstacles, and to disseminate the results of these projects. More concretely, it examines the use of forecasts to direct land management decisions in the fire-prone savannahs of northern Australia. In this region, Indigenous (Aboriginal) and Euro-Australian land managers use forecasts to set the time and level of controlled fires. These fires reduce the fuel load so that catastrophic fires are avoided, and they also serve to manage vegetation (to increase fodder and support wildlife, and also to conserve biodiversity through maintaining the mosaic of different types of plant communities). Indigenous and Euro-Australians often misunderstand each other's behaviors and rationales for behaviors. However, each group would benefit by learning from the other and by coordinating their forecast use and fire decisions more closely. The research will focus on three sites to consider a range of different relations between the two groups and a range of environmental parameters. The project establishes close cooperation with the School of Geography and Environmental Science at Monash University in Melbourne.

B. Objective of Research Report

The objective of this report is to present the project's activities in this project, with an emphasis on field visits, interviews, archival research and remote sensing. Interactions with the climate forecast community, with end-users and with other researchers are described. Preliminary results

are presented in several areas: It contains a discussion of changing institutional and policy framework for fire management in northern Australia, a report on the use of remote sensing to describe and analyze patterns of fire starts and spreads, and some findings about the relations between traditional and modern environmental monitoring and forecasting. It emphasizes the potential compatibility between these different knowledge systems and the promising initial efforts to bridge them, while also recognizing the institutional obstacles to such integration.

C. Approach. The approach includes a number of components.

ethnographic research. This research took place in rural settings with Indigenous Australians and Euro-Australian pastoralists and in agency settings for meteorological, resource and fire management organizations. Ethnographic techniques in socio-cultural anthropology were used to establish the patterns of forecast production, distribution and use in both systems. This research began with the identification of key informants and extended conversations with them. Open-ended interviews and participant observation with a wider set of individuals established recent history and current practices regarding environmental monitoring, forecast preparation and decision-making regarding fire starts [Bernard 1988]. Particular care was taken to respect Indigenous views of privacy and of restrictions on circulation of information. An important point in this project is that ethnographic research was being conducted among both Indigenous Australians and Euro-Australians.

fire logs. We had planned to ask a sample of Indigenous Australian and Euro-Australians, including both residents and managers, to keep fire logs in which they record fire starts and fire histories. Rather than imposing one set of categories on all users, we encouraged users to record fires using their customary categories, whether traditional or scientific. This technique of local monitoring could used to assess local environmental perception. We discovered that the Euro-Australian government and land management agencies use highly automated systems based on remote sensing, so that the information on fires is archived, and consulted with varying frequencies by different users. We discovered as well that Aboriginal Australians, though highly sensitive to fire starts (they often detect fires by smell, by observing smoke and by observing the flight of birds of prey that travel to fires to capture animals that escape the flames), do not have regular procedures for observing fires systematically, but rather remain alert to information that allows them to revise their knowledge of each fire: in a sense, they consider each fire as a unique occurrence. We also found that Aboriginal Australians were reluctant to commit to regular keeping of written records; obversely, we discovered that they were enthusiastic users of video equipment, and took detailed video records of individual fires, including repeated visits to the sites of fires months and years afterwards. As a result, we were not able to use fire logs in a systematic way, but we did confirm the deep connection of Aboriginal Australians to their areas, and their close knowledge of particular sites.

remote sensing. This project integrated ground-based and remote sensing data, a link that has been extensively developed in other tropical areas. In this study we have a seven-year program of monitoring fire activity (marked by developing fire scars) at each of the field research sites. Since we are concerned with areas of several hundred km^2 in each case, we use the MODIS satellite data (250 m or better pixel size) available from the ACRES website in Australia (http//www.auslig.gov.au/acres/prod_ser/modisprice.htm). We developed routines to automatically capture these site-specific data on a regular basis throughout this study. A geographer at Monash University, Sarah Burns, imported the data to ERDAS IMAGINE and

uses change detection algorithms to map the developing fire scar mosaics at each site through the season by using monthly images. She overlaid this information will be overlain over a digital elevation model (DEM) of each region. All of this work is carried out within the GIS Laboratory at Monash University and covers the fire seasons of 2000-2007. In addition, she conducted a coarser-grained analysis (1 km pixel size) using NOAA AVHRR data on a monthly basis across northern Australia for a slightly longer period, 1997 – 2007. This dataset gives total area burned each month, average size of fires and number of fires

archival data. Extensive archives on land title and use, resource utilization patterns and social/political processes are available at the state/territorial and national level in Australia. The archives for documenting Aboriginal history are far richer than in many other nations. These materials provide a time depth to the study and help clarify the institutional dynamics of access to land.

D. Description of matching funds

There are no direct matching funds for this project. Australian collaborators received some office and logistical support from their home institutions, particularly Monash University.

II. Interactions

A. Interactions with decision-makers

The attention to bushfires continues to grow in northern Australia, building on the longstanding awareness of the importance of fires in Australia as a whole, and connected to the devastating drought (the "big dry") that has affected the major urban and agricultural regions in the southeast, the continued importance of land management for biodiversity, and the increasing attention to adaptation to climate change. It would be a great overstatement to claim that my presence or this project form key catalysts to the development of links among these groups. There are many impulses towards coordination, towards regional management, and towards the recognition of multiculturalism within Australia that allow for greater engagement with Aboriginal knowledge. Nonetheless, the presence of a foreign researcher, and the visits that I make, may provide some small amount of impetus to promote these connections. I also provide support to key individuals and offer experiences from other regions of the world.

At a national level, my contacts with the Bureau of Meteorology (facilitated by its location in Melbourne, close to Monash) contributed to the Bureau's interest in indigenous climate knowledge and forecasting (see below).

In the Queensland site, my ties with the Cape York Peninsula Development Association supported their involvement with Cape York Peninsula Sustainable Fire Management project, funded by the Natural Heritage Trust. It has established a steering committee to direct the project, composed of community and government representatives. Drawing on work conducted under this grant and from other sources, it closely studies existing fire regimes and establishes best practice fire management to accomplish a number of goals: sustainable livestock production, conservation of biodiversity, and support of traditional Aboriginal practices. Several projects, totaling over AU$250,000, support rehabilitation of pastoral land, sustainable grazing, and natural resource management on the Cape York Peninsula. Aboriginal groups, including the Cape York Land Council and Balkanu Cape York Development Corporation, are hopeful that this project will generate ongoing employment for Aboriginal youth in environmental careers.

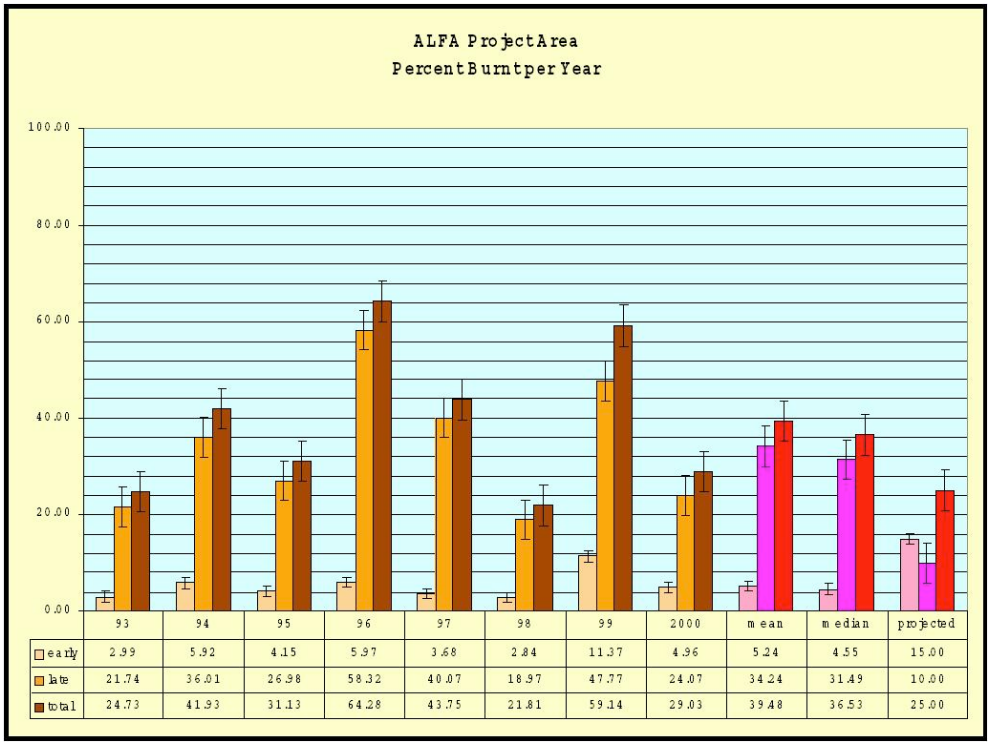
In meeting with the Queensland Parks and Wildlife Service, I have supported the staff who have sought to shift from autonomous fire management under its comprehensive Fire Management System, using primarily remote sensing techniques to plan, implement and monitor fires, towards coordination with Aboriginal groups. The Service has employed Aboriginal rangers involved in planning, initiating and tracking fires. Even the Queensland Rural Fire Service (a division of the Queensland Fire and Rescue Service, which in turn is a component of the Queensland Department of Emergency Services) is expressing some interest in Aboriginal management and practices; this service, squarely in the hands of pastoralists in Cape York, had been relatively closed to such interactions.

In the Northern Territory site, my ties were with a wider variety of organizations. NAILSMA, the North Australia Indigenous Land and Sea Management Alliance, is an Aboriginal organization that supports indigenous involvement in environmental management and sustainability and that works for greater indigenous rights in land tenure. Working with the Kimberley, Northern and Carpentaria Land Councils and Balkanu Cape York Development Corporation, it supports a number of activities related to continuing Aboriginal fire management and to integrating Aboriginal land management with public lands policies.

I worked closely with the Traditional Knowledge Recording Project in its initial phase and under its new name. It supports r community development through the revival of traditional (indigenous) knowledge within contemporary society . It works closely with traditional elders to record knowledge and to pass this knowledge on to younger generations. The Traditional Knowledge Revival Pathways was developed from the aspirations of Indigenous Elders, to preserve and recognize Traditional Indigenous Knowledge. With the guidance and instruction of our Aboriginal Elders, we are supporting them to collect information that will be beneficial for County and Community, both in the present and the future." It continues its emphasis on fire and related areas of land and water management, and has extended its activities beyond Kuku Thaypan country around Laura and Lakefield National Park to much of the Cape York Peninsula, other nearby areas in Queensland such as Mackay and the Atherton Tablelands and the savannah regions that drain into the Gulf of Carpentaria from the south. A sample fire video is available at http://www.youtube.com/watch?v=GS46w704T18

The West Arnhem Fire Management Agreement (WAFMA) is a partnership between Darwin Liquefied Natural Gas (DLNG), the Northern Territory Government, the Northern Land Council and relevant Aboriginal Traditional Owners and indigenous representative organizations, formed to implement strategic fire management in the 28,000 km^2 Western Arnhem Land Fire Abatement project area for the purposes of offsetting greenhouse gas emissions from the Liquefied Natural Gas plant at Wickham Point in Darwin Harbor. The project emphasizes the importance of methane and nitrous oxides from bushfires—about 41% of the greenhouse emissions from the Northern Territory and around 2% of Australia's total greenhouse emissions. The project's first phase will be in the western portions of Arnhem Land, including Maningrida. About 10% of the project area's landscapes are affected by early dry season fires and from 30–60% are affected by late dry season wildfires in most years. If the proportion of early dry season fires can be increased to around 15–20% to create fire breaks and patchy mosaics of burned country and if this then reduces the extent of late dry season burning to 15–20% of the landscape, then savings (abatement) of around 100,000 tons a year of CO_2-equivalent in greenhouse gas emissions can be made. CONOCO-Phillips signed an agreement with the Northern Territory government in September 2006 to pay up to AUD 1 million per year to employ Aboriginal

people from western Arnhem Land to initiate early season fires; though the detailed planning of these fires is not yet complete (and may not ready completion during the 2007 fire season), it is nonetheless a great step forwards towards the integration of different forms of fire knowledge and practice, one that would have been unimaginable even a few years ago. Images below show aspects of this project.



	93	94	95	96	97	98	99	2000	mean	median	projected
early	2.99	5.92	4.15	5.97	3.68	2.84	11.37	4.96	5.24	4.55	15.00
late	21.74	36.01	26.98	58.32	40.07	18.97	47.77	24.07	34.24	31.49	10.00
total	24.73	41.93	31.13	64.28	43.75	21.81	59.14	29.03	39.48	36.53	25.00

Projected shifts in fires (note overall reduction and shift to early season fires)

Ground-based fire ignition

Assessing impacts of hot fire late in the dry season

Motorized vehicle for initiations of cooler fires early in the dry season

B. Interactions with climate forecasting community

Linkages to the Australian forecasting community have continued through Neville Nichols, a leading atmospheric scientist at the Australian Bureau of Meteorology who has recently taken up an appointment in the School of Geography and Environmental Science at Monash University. I worked with the Bureau of Meteorology to help set up their Indigenous Weather Knowledge site (http://www.bom.gov.au/iwk/). My appointment as an Adjunct Senior Research Scientist at the International Research Institute for Climate and Society also places me in contact with groups that develop and disseminate forecasts.

I have had contacts with climate applications specialists. At meetings at the Tyndall Centre for Climate Change Research in the UK, I have discussed issues of incorporating indigenous knowledge into the development of forecast products. I have also consulted with the World Bank on issues of impacts of climate variability and climate change on indigenous peoples.

III. Accomplishments

A. Brief discussion of research tasks accomplished

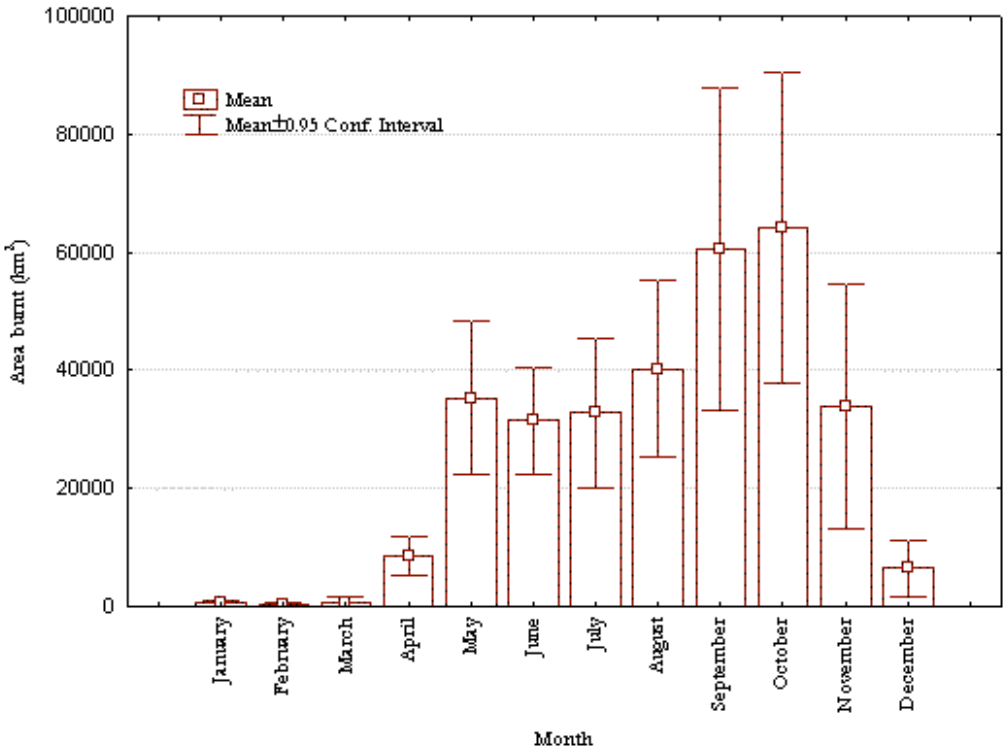
The northern Australian region, for the most part, has a tropical climate influenced by its proximity to the coast and is characterised by hot, wet, humid summers and dry winters. High rainfall and temperature during the summer enables strong vegetation growth and is followed by dry hot days (daily maximum temperatures over 30°C) in the dry season. These conditions lead to the rapid drying of grassy fuels that result in highly flammable conditions. Three study regions were chosen for this project to provide an overview of fire activity across northern Australia. The

regions include Kalumburu in Western Australia, Maningrida in Northern Territory and Laura in Queensland (**Error! Reference source not found.**). The study areas were chosen based on their spatial distribution across the Australian savanna in three different states all within approximate latitude of 12° S to 15° S. The study areas are all relatively remote, as they are all located a few hundred kilometres from the nearest city, with little infrastructure in place. All of the study areas are relatively small (approximately 115 km x 115 km) to enable moderate resolution analysis of the region. Moreover, they all include several types of fire managers: Aboriginal Australians, pastoralists and government land managers.

The project used data from Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the NASA Terra and Aqua spacecrafts. MODIS has thirty-six spectral bands with resolution ranging from 250 metres to 1000 metres. MODIS is ideal for monitoring large-scale changes in the biosphere, providing a better understanding of the global carbon cycle. MODIS bands are also particularly sensitive to fire. Bands one and two are at a resolution of 250 metre. Although limited they fall into the range of red and near-infrared wavelengths which are among the most important spectral regions for remote sensing of vegetation MODIS has daily acquisition, easy accessibility, and improved radiometric and spatial characteristics when compared with previous high- and coarse- resolution sensors such as Landsat and AVHRR respectively. We used change detection for its ability to delineate newly burned regions and exclude old burns. Using the minimum near infrared values the newest regions are clearly evident compared with any change detection from an old burn changing over the season. Change detection worked by taking one image and subtracting it from an earlier image. This process reported any changes between the two images for band 2 (near infrared). Following classification, further processing was required to clearly identify and extract the burned areas. The data were converted from raster to vector and the polygons were dissolved to combine all polygons. They were recoded to select only the classes that were identified as burned and then edited from multi-part to single-part so that each polygon could be manipulated. The areas of each polygon were calculated. Burn scar detection processing includes inherent commission and omission errors. The commission errors that were found in this study were due to sun glint, cloud shadow, cloud cover, and edge effect of coastal regions and river ways. Omission errors included regrowth, small fires and low intensity burning that did not result in a change to the surface. These problems were generally overcome by visual identification. Visual identification of burn scars was conducted using editing tools in ArcMap 9.2. The burned area data were visually analysed in conjunction with the original image, the change detection output (before post-processing) and with topographical data such as roads and water bodies. Where required the boundaries of the burn scars were digitised on-screen.

This extensive work generated interesting findings about the similarities and differences between the sites, about the associations between interannual variability and fire, and about the interaction of natural and human factors in the patterns of fire.

The following figures and discussion review the results. As shown below, the total burned area in northern Australia shows a strong annual cycle, but varies from year to year both in terms of total amount of area burned and in the distribution of burning across the months of the fire season.



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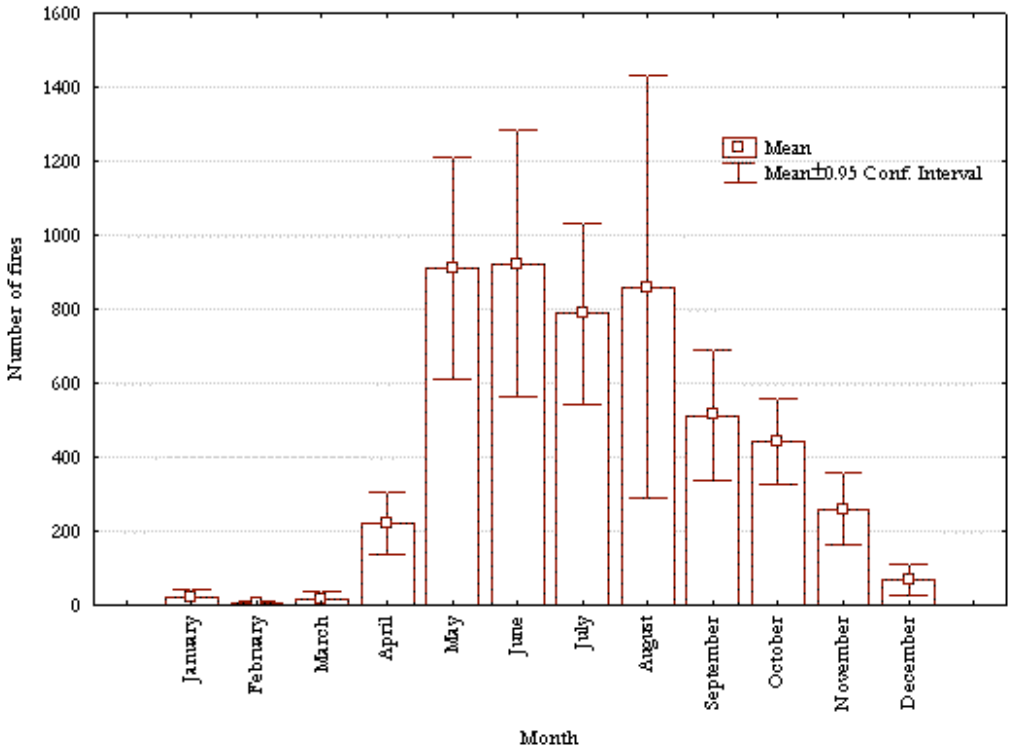
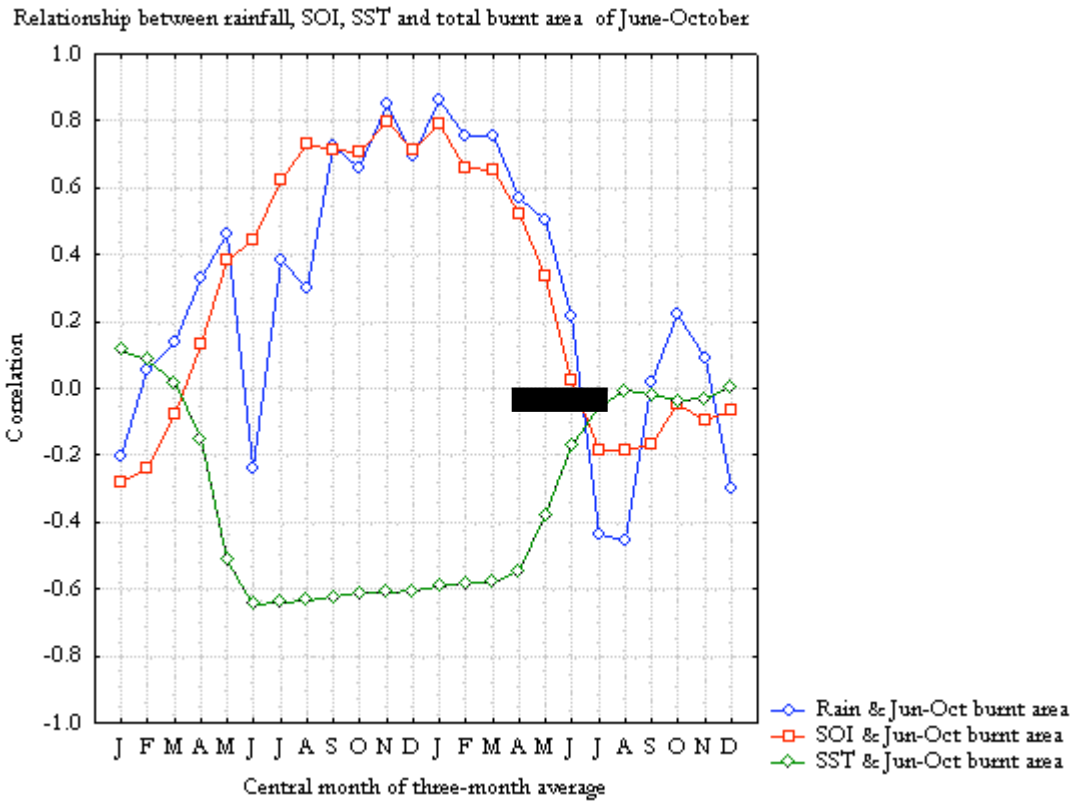
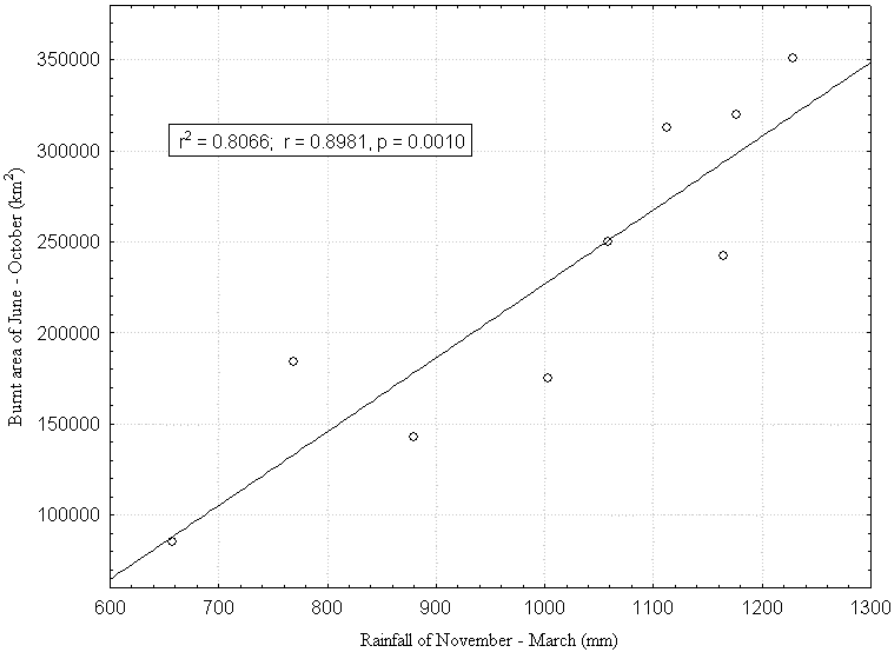
The average season shows a strong concentration in May through November, with the greatest amount of burning in September and October, months conventionally understood as being late in the season. This seasonal variation is due both to the total number of fires and the average size of fires. The months of most numerous fires are May through August, and seem to include many anthropogenic fires. However, the late season fires, especially in September and October, are larger (they may also be presumed to be hotter and more destructive, and, though the more extensive combustion, to release a greater volume of gasses).

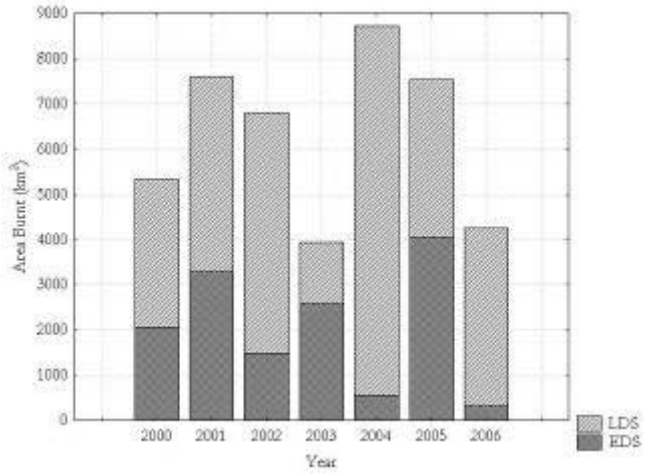


There is a strong relationship between ENSO with rainfall and with burned area. In Australia, the Southern Oscillation Index (SOI) is a measure of ENSO frequently used in addition to seas surface temperature (SST) in ENSO zones 3 and 4. It is striking to see the high correlations (0.6-0.9) between SOI and burned area with a lead time of 6-12 months, and between rainfall and burned area with a slightly shorter lead time. In other words, SOI serves as a predictor of burned area—a very useful piece of information for individuals and organizations involved in managing fires and land.

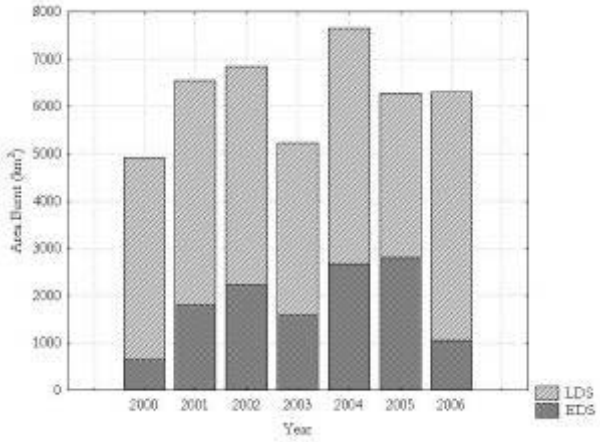

Relationship between rainfall, SOI, SST and total burnt area of June-October
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
J F M A M J J A S O N D J F M A M J J A S O N D
Central month of three-month average
Rain & Jun-Oct burnt area
SOI & Jun-Oct burnt area
SST & Jun-Oct burnt area


r^2 = 0.8066; r = 0.8981, p = 0.0010
Burnt area of June - October (km^2)
350000
300000
250000
200000
150000
100000
600
700
800
900
1000
1100
1200
1300
Rainfall of November - March (mm)

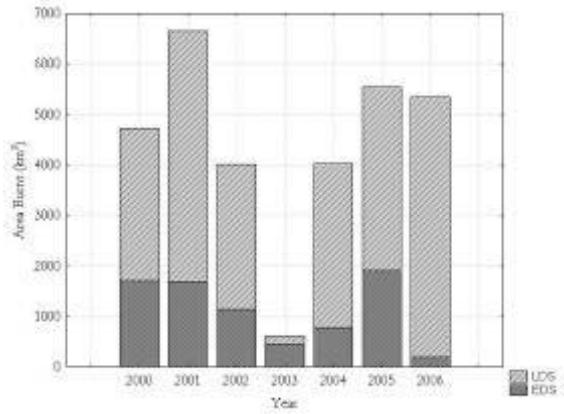
There is also variation between regions and between years in the distribution of fires between the early dry season (EDS) and late dry season (LDS).



Annual burned area of the Kalumburu study area with EDS and LDS proportions burned delineated, 2000-2006

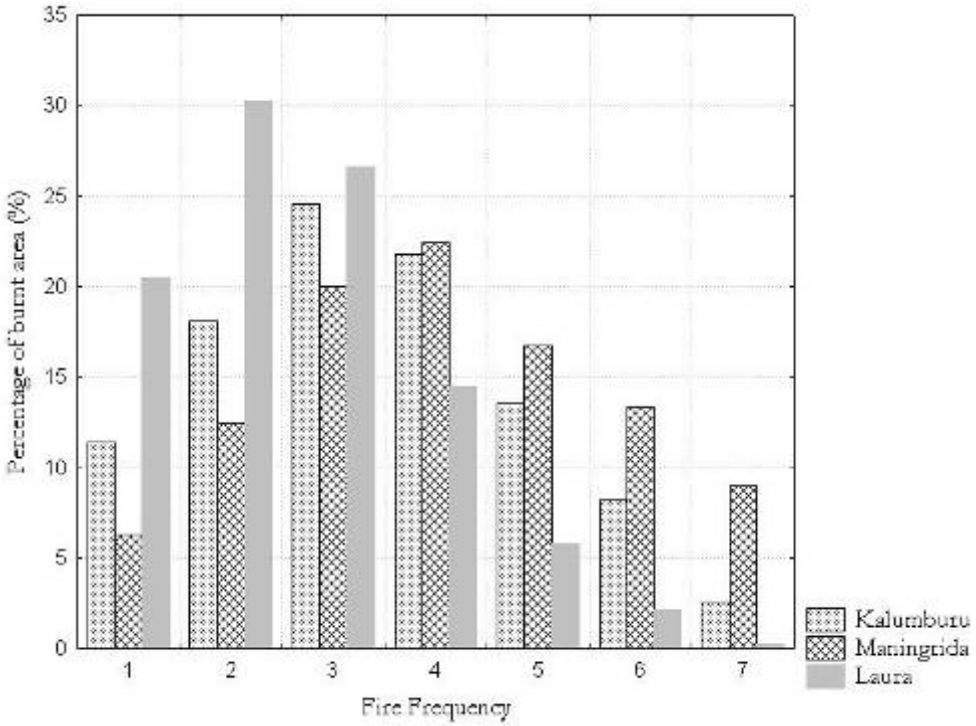


Annual burned area of the Maningrida study area with EDS and LDS proportions burned delineated, 2000-2006



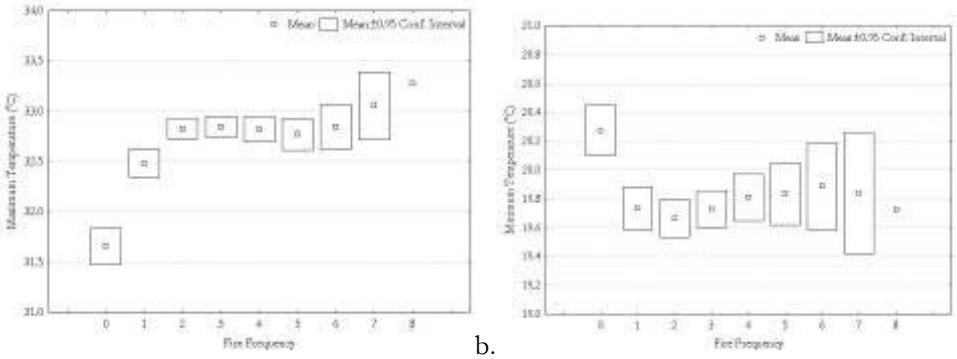
Annual burned area of the Laura study area with EDS and LDS proportions burned delineated, 2000-2006

The areas also show significant variation in the fire-return frequency, as measured during the 7-year study period. The Laura study area has the greatest positive skew, then the Kalumburu study area with the Maningrida study area showing the most pronounced normal distribution. 46% of the burned areas in the Kalumburu study area burned four or more times out of the seven years. 61% of the burned areas of the Maningrida study area burned four or more times in contrast with the Laura study area where only 23% of the burned areas burned four or more times.



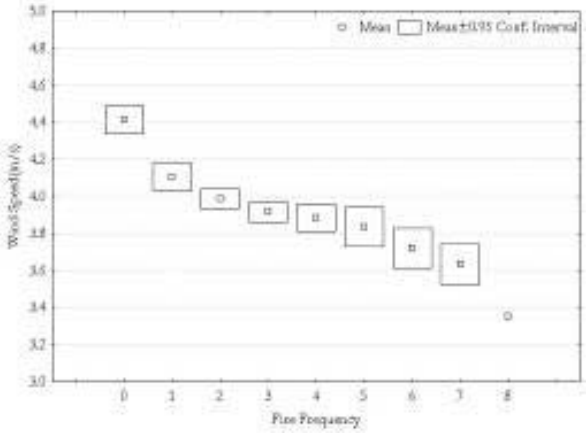
Fire frequency of burned areas for the Kalumburu, Maningrida and Kalumburu study areas, 2000-2006

Fire frequency is positively correlated with mean daily maximum temperature and negatively correlated with mean daily minimum temperature, and also with the frequency of lightning flashes, a major source of ignition, particularly in the late dry season. More surprisingly, the relationship with wind is the reverse of what has been found elsewhere. In this study, regions with higher annually averaged wind speeds burned less often. The differences in results could be due to several; factors. Firstly, regions that are affected by a sea breeze could result in lower fire activity due to the cooler temperature and higher humidity that the sea breeze brings. Secondly, the differences could also be because the windiest areas are those coasts exposed to moist south-east trade winds.

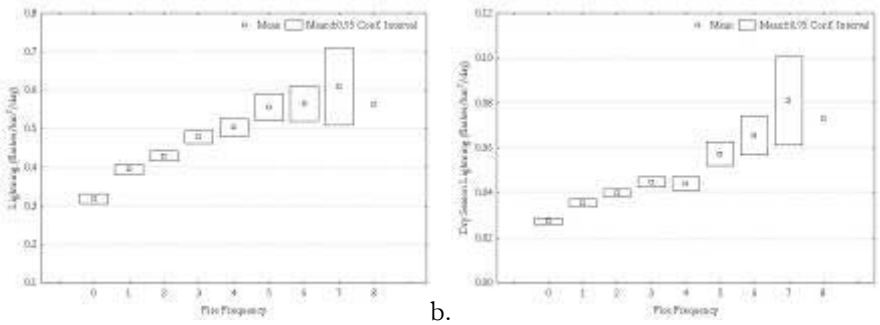


a. b.

Mean (a) maximum and (b) minimum temperature with fire frequency of northern Australia, 1997-2006



Mean average annual wind speeds and fire frequency of northern Australia, 1997-2006



a. b.

Average number of flashes/km^2/day for the (a) dry season (June-October) and (b) annually with fire frequency, 1997-2006

Local knowledge. The material gathered shows that local knowledge interacts in complex ways with political systems. The networks that are currently bridging Aboriginal and pastoralist communities with each other and with government land management agencies all have somewhat different understandings of the nature of "traditional environmental knowledge". Though Aboriginal groups generally welcome the recognition of their knowledge and practice, they are sensitive to losing control over this knowledge. A frequently reported concern is that if the knowledge is written down and recorded, then others can claim to act on the basis of it; more concretely, the managers of protected areas could say that they are applying traditional knowledge (pointing to a published document that describes such knowledge) without any actual participation of Aboriginal people. The Aboriginal knowledge is often more situational and contextual than these managers realize, but this contextual nature, in turn, makes coordination between different groups more difficult.

As part of this project, a number of traditional stories relating to bush fires were collected in the local language (Yir Yoront) in western Cape York. These stories are rich in detail, depicting animals and humans in the mythical past period of the world's beginning (Dreamtime). They show the great cultural importance that maintaining fire regimes holds for Aboriginal Australians, and they generally support the strong association between particular kin groups (linked to mythical ancestors) and places. They also contain some details of fire practices, such as the burning of grasses and low plants rather than trees. However, they do not encode details about the time of day or year to burn, the selection of relative humidity and of wind velocity and direction at the time of burning, and so forth; these are transmitted through conversation and direct observation.

Contexts of use of forecasts. One of the most striking findings was the dramatic change in the political situation of Aboriginal peoples within Australia in general, and in the organization of fire governance in northern Australia in particular. These changes are working in opposite directions, since there has been a reduction in Aboriginal self-governance at the national level but at least some increases at the state and territorial level.

At the national level, the Aboriginal and Torres Strait Islander Commission was founded in 1989 to allow greater Aboriginal autonomy. It grouped many programs linked to Aboriginal peoples within a single agency, under Aboriginal leadership and management. The established of ATSIC was linked to the movement for the recognition of Aboriginal land title that unfolded in the

1980s and culminated with a major court decision in 1992. In April 2004, the government, led by the conservative Liberal Party, decided to end ATSIC and to disperse programs linked to Aboriginal peoples back to different ministries. It argued that ATSIC was corrupt and inefficient, and it also drew upon a backlash against Aboriginal rights in certain sectors of Australian society. The opposition Labour Party, which generally has supported Aboriginal causes, agreed with this plan, though they called for some official organization to represent Aboriginal peoples directly. In 2005, Aboriginal Affairs were transferred to Department of Families, Housing, Community Services and Indigenous Affairs. This shift directly affects the numerous Aboriginal organizations that are involved in supporting traditional fire practices, and has many indirect impacts on local communities as well. Though the new organization has laudable goals—improving health, life expectancy and education, reducing domestic violence—it also undercuts Aboriginal organizations, and supports educational programs that downplay indigenous knowledge and culture. Its vision of economic development for Aboriginal lands centers on private enterprises, including increased mining concessions on Aboriginal lands, which are frequently incompatible with traditional burning. Moreover, this move favors a view of Aboriginal progress through government intervention in domestic affairs (following highly visible cases about domestic violence and sexual abuse) rather than through longer-term economic development and empowerment. Though the Labour Party, which came to power in national elections in 2007, is generally more supportive of Aboriginal rights and autonomy than other parties, the heyday of Aboriginal rights in the 1990s and early years of this decade seem over.

At the state and territorial level, fire management has been restructured. In the Northern Territory and Queensland, rural fire brigades grew out of self-help organizations of largely autonomous Euro-Australian pastoralists, who set fires to reduce shrub encroachment and who worked together to control wildfires. These organizations were strongly opposed to Aboriginal burning. In the Northern Territory, the principle organization is the Bushfires Council of the NT, part of the NT Department of Infrastructure, Planning and Environment, which was created in November 2001 from the Department of Transport and Works, the Department of Lands, Planning and Environment, and Parks and Wildlife Commission of the NT. The NT has been divided into nine Fire Control Regions corresponding to the diverse climates, soils, vegetation and economic activities in this large and sparsely populated territory. In 2004, a tenth Region was created that includes the large Aboriginal Reserve in Arnhem Land, the relatively strong Aboriginal area of Groote Eylandt, the internationally known Kakadu National Park (which has a significant level of Aboriginal co-management) and the important, though not as well known, Cobourg National Park. The members of the committee that will govern this Region will be Aborigines. This substantial change led to increased Aboriginal participation in other Regions, such as Arafura, Victoria River Downs, and Alice Springs West and East. In Queensland, the Rural Fires Service has responsibility under the Queensland Fire and Rescue Service for managing fire across rural zones, which constitute 93% of this large state, with extensive pastoral areas. The state is divided into fifteen Districts. The northernmost Cairns Peninsula District includes the extensive Aboriginal lands on the Cape York Peninsula; this area also contains Lakefield National Park, a large park which consists of former pastoralist estates, which had been under effective Aboriginal control until early in the twentieth century. In 2003, the Queensland Parks and Wildlife Service, which manages national parks within the state, allowed Aborigines whose clans formerly resided on these lands to return to them. They promoted

Aboriginal co-management of fire, though these relations rested on personal ties between key individuals, and thus may not prove long-lasting.

These competing trends work out in different ways in different settings. To offer one example, Kakadu National Park in the Northern Territory has been seen as an area of highly positive cooperation between government land managers and local Aboriginal residents, yet the latter are still marginalized. Although there is a move towards more centralized fire management within the park based on land system units, fire management is still largely controlled by smaller districts, which have considerable authority in how they implement the fire program. Across districts, fire is employed as a hazard reduction tool rather than an ecosystem tool per se. Priority for hazard reduction burns descends from protection of buildings as first priority, then protection of the park's borders to keep fires from spreading in or out (to neighboring pastoral estates and Aboriginal lands), protection of monsoon forest, sites of Aboriginal cultural significance such as rock art sites and sacred waterholes, and finally broad scale breaks, particularly along creek lines, against late season fires. Though certain Aboriginal sites are protected, and local Aboriginal rangers receive pay to start fires, the timing and location of fires are largely determined by government land managers, with little input from the Aboriginal residents.

C. List of papers and presentations

2005. Nicholls N. Climate and culture connections in Australia. Australian Meteorological Magazine 54(4):309-319

2006. Burns S. Sharing Knowledge: A Workshop on Climate Change Impacts and Adaptation Strategies for Northern Australian Indigenous Communities 29-31 March 2006. Darwin, Northern Territory, Australia

2006. Burns S. Regional Responses to Global Changes: A view from the Antipodes. International Geographical Union Regional Conference Brisbane, Australia.

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IV. Relevance to the field of human-environment interactions

A. Contribution of results to field of use of climate information

This work demonstrates the importance of the institutional context of climate information. Individuals may draw on one or both systems of climate information to assess the time and location of fire starts. However, their access to territory in order to start fires depends on the particular systems of regulations, which have varied considerably in recent decades.

It is interesting to note too the cultural overlays of climate information. Aboriginal groups take great pride in the depth of their knowledge of country. They feel that the length of their experience and the intimacy of their knowledge give them a strong basis for determining burning patterns. They are concerned to pass this information on to future generations. Quite similar statements could be made about the views of the Euro-Australian pastoralists, who have been resident in northern Australia for at least three or four generations, and in many cases five or six, and who These statements could apply as well to the planners and resource managers, whose knowledge derives from international science rather than from local knowledge.

Nonetheless, there are many points of overlap among these groups, who find complementarities between their technologies and methods of transmission of information. Even though obstacles face the coordination of indigenous and national agencies in managing fires, Australia has progressed far beyond the United States in this regard. It is very hard to imagine that the US National Park Service would consider co-managing fire in Yosemite with Miwok, as the Queensland Parks and Wildlife Service is doing with Kuku Thaypan in Lakefield National Park, or that the US Forest Service would allow fire in Apache National Forest in Arizona to be co-managed with the Apache (for whom the forest is named), as the NT Bushfires Council is currently allowing.

B. Links to other HDGEC research

Other NDGEC studies have demonstrated the detail of local systems of knowledge of climate variability. They have shown that local indicators can be used to observe the progress of seasons and to accommodate interannual variation. Phillips and Orlove's work in Uganda has shown the close attention to local 'signs' (such as shifts in wind direction, changes in nightly minimum temperature, and arrival of migratory birds) to indicate the onset of rains. Farmers in several language groups in southern Uganda use this information to determine the timing of field preparation, the selection of crop varieties, and the patterns of livestock movement. The pattern of transmission of information seems more broadly diffused through society, since the signs and their significance are topics of common conversation rather than part of a more institutionalized transmission process as in Australia. Kirshen's project in Burkina Faso in West Africa shows generally similar results. Valdivia, Gilles, Quiroz and Jetté have shown that indigenous farmers in highland Bolivia similarly monitor the progress of the seasons to choose planting dates for their principal crop, potatoes; here, the knowledge appears to be less widely diffused, since different individuals often do not discuss the signs that they observe with others.

C. Contributions to study areas

Adaptation to long-term climate change. These cases show the variability in time-scale with which human groups adapt to environmental variability and change. The detailed Aboriginal knowledge of seasonality comes from the millennia of residence in the region. The Euro-Australian pastoralists have lived in the region for several generations, enough to witness considerable variation, and there is evidence as well that they adapted some burning techniques from the Aborigines who worked on their ranches

Institutional dimensions of global change. This work bears directly on mitigation strategies for climate change. Discussions have already begun about the importance, within the context of greenhouse gas emissions, of fires in the eucalyptus woodlands of northern Australia. Since there is spatial and temporal variability in burning patterns, and since fires differ in terms of the heat at which they burn and the percentage of fuel which is burned, there is also variability in the quantity and composition of gasses that are released. This variability may also influence the storage of carbon in plants and soil. This may well lead to debates over the responsibility for the emissions (fires set by different groups may release different amounts and types of gasses associated with climate changes) and with credit for the emissions (different groups could claim credit to trade carbon emission rights in some global exchange system).

Developing tools for decision-makers and end-users. Two very different groups have both made extraordinary leaps to the use of remote sensing and web-based technology: Aborigines, who have displayed a tremendous facility with the use of digital photography and whose pre-modern patterns of use of graphic icons in story-telling (as in the case of drawing in the sand) seem to offer a pre-adaptation to the Internet, and pastoralists, who have overcome a historical opposition to more educated professionals from distant cities in southern Australia to make use of radio (since the founding of the School of the Air in 1951, following in a way on the Flying Doctor Service that started in 1928). They demonstrate the importance of the development of long-term relationships between agency staff and end-users for the eventual acceptance and use of this technology.

Matching new scientific information with local/indigenous knowledge. Australian government agencies have shown a great willingness to acknowledge indigenous knowledge. There are

certainly few counterparts to the Australian Bureau of Meteorology's website on Indigenous Weather Knowledge (www.bom.gov.au/iwk). However, there remain significant difficulties in the implementation of the joint use of this information, since some agencies are unwilling to modify their procedures to allow for the social (rather than the knowledge-based) aspects of indigenous resource management (including the lack of written plans, the importance of face-to-face conversation in decision-making, and different forms of property rights).

Role of public policy in the use of climate information. The case of Australian bushfire management demonstrates the multiple levels of policy formation. The recent trends in that country are contradictory: weakening support of Aboriginal resource management at the national level, increasing support at the state and territorial level, ongoing tensions at the local level, and growing global and international governance of activities linked to emissions of greenhouse gasses and carbon sequestering.